Multi-frequency data analysis in AFM by wavelet transform

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Interacting cantilevers in Atomic Force Microscopy (AFM) experiments generate non-stationary, multi-frequency signals consisting of numerous excited flexural and torsional modes and their harmonics. The analysis of such signals is challenging, requiring special methodological approaches and a powerful mathematical apparatus. The most common approach to the signal analysis is to apply the Fourier transform (FT) analysis, which decomposes the signal into constituent frequencies displayed in the spectrum as resonance peaks. FT analysis gives accurate spectra for stationary signals. For signals changing their spectral content over time, FT provides only an averaged spectrum. Hence, for non-stationary and rapidly varying signals, such as those from interacting AFM cantilevers, a method that shows the spectral evolution in time is needed. One of the most powerful techniques, allowing detailed time-frequency representation of signals, is the wavelet transform (WT). WT is a method of analysis that allows representation of energy associated to the signal at a particular frequency and time, providing correlation between the spectral and temporal features of the signal, unlike FT [1, 2]. This is particularly important in AFM because signals nonlinearities contains valuable information about tip-sample interactions and consequently surfaces properties [3-5]. The present work is aimed to show the advantages of WT in comparison with FT using as an example the force curve analysis in dynamic force spectroscopy.

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